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Indian Stadnard

REQUIREMENTS FOR WATER FLOW MEASUREMENT IN OPEN CHANNELS – ROTATING ELEMENT CURRENT METERS

(First Revision)

UDC 681·121'8 : 532·57

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

July 1992 **Price Group 4**

Fluid Flow Measurement Sectional Committee, RVD 1

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Fluid Flow Measurement Sectional Committee had been approved by the River Valley Division Council.

In the field of management of water resources, precise measurement of flow is an essential prerequisite. Of late, this measurement has assumed new dimension in the role of flow distribution/sharing between adjacent states or neighbouring countries.

For undertaking such measurement of flow, current meters are generally deployed. In India, current meters with cup type rotating element were mostly used drawn from various makes and models. To provide guidance to the user as well as to the manufacturer in respect of this type of current meters, this Indian Standard was first published in 1966.

Gradually current meters with other types of rotating elements came into being in Indian use and range of produce. Therefore, the need to update the existing standard, covering other common types of rotating elements also was felt and therefore this revision has been formulated. This standard is based on ISO 2537 : 1985 and covers the requirement based on indigenous manufacturing practice, which is in developing stage. As and when improvement is made in undigenous manufacturing this standard will be updated.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

REQUIREMENTS FOR WATER FLOW MEASUREMENT IN OPEN CHANNELS — ROTATING ELEMENT CURRENT METERS

(First Revision)

1 SCOPE

This standard specifies the operational requirements, constructional guidelines and maintenance of rotating element current meter for the measurement of flow velocities in the open channel.

2 REFERENCES

The Indian Standards listed below are necessary adjuncts to this standard:

IS No.	*Title*
1191 : 1971	Glossary of terms and symbols used in connection with the measurement of liquid flow with a free surface (*first revision*)
1192 : 1981	Velocity area method for measurement of flow of water in open channels
3918 : 1966	Code of practice for use of current meter (cup type) for water flow measurement

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 1191 : 1971 shall apply.

4 PRINCIPLE OF OPERATION

4.1 Proportionality

The rotating element of a current meter is driven by the fluid at an angular velocity which is proportional to the local velocity of the fluid at the point of immersion when that velocity exceeds a critical value.

The velocity of fluid is determined by counting the number of revolutions of the rotor during a specified time interval or by observing the time required by the rotor to turn a given number of revolutions and consulting the meter calibration table or rating equation. The velocity of fluid movement may be determined from the sensing of signals emitted (such as electrical pulses) through the rotation of the rotor. The velocity may be determined from a direct reading of the speed of rotation of the rotating element by means of equipment designed for this purpose.

NOTE – The axis of the rotating element may be at right angles or it may be parallel to the direction of flow.

5 TYPES OF CURRENT METER

5.1 They have been classified according to the type of rotating element used.

5.2 Cup Type Current Meter

A rotor (bucket wheel) generally formed out of conical cup and curved vanes attached at equal intervals around the perimeter of the hub which will rotate when placed in the fluid flow. It is usual to mount the rotor with the axis vertical. Typical constructional features are given in Annex A.

5.3 Propeller Type Current Meters

Assembly consisting of 2 or more helical screw blades formed around a hub or a number of flat plates attached at equal intervals around the perimeter through twisted spoke that will rotate around a horizontal axis when placed with fluid flow.

5.4 Savonious Type Current Meters

The rotor is an assembly of a number of curved vanes (of the formation of a turbine rotor) attached at equal intervals formed around a vertical axis.

NOTE - Miniature current meters generally are of cup type and propeller type as mentioned above in 5.2 and 5.3.

6 OPERATIONAL REQUIREMENTS

6.1 Positioning

6.1.1 The longitudinal axis of the free suspension type current meter shall take-up stable position parallel to the direction of flow without excessive twisting and turning under the influence of local eddy currents.

6.1.2 It shall dynamically balance in the stream with its longitudinal axis parallel to the water's surface and shall have sufficient freedom of movement in the vertical plane to ensure the assumption of the position.

NOTE — Generally for miniature current meters, conditions under 6.1.2 are difficult to practise.

6.2 Relationship of Rotor Movement and Stream Velocity

The rotating element of the current meter shall be such

that when driven by the fluid, it rotates at an angular velocity which has a known relation to the velocity of the flow within the calibrated velocity range stated by the rating laboratory.

6.3 Limits of Use

6.3.1 *Various Liquids*

The current meter shall be used only in liquid with properties similar to those in which the meter was calibrated. If the liquid properties are significantly different, the meter shall be recalibrated in a liquid with properties similar to that in which the meter is to be used.

Unless otherwise indicated, the current meter shall be capable of being used in waters containing suspended sediment and in saline waters.

6.3.2 *Cup Type Current Meters*

Vertical components of velocity may cause rotation of a hollow-cup type current meter. When there is considerable turbulence in a stream or where there are otherwise significant vertical components of velocity, hollow-cup-type meters may over-register. Usually the over-registration will be small unless large vertical components of velocity relative to the horizontal components are encountered.

6.3.3 *Savonius Type Current Meters*

Under combined action of flow and wave, rotors with blades having higher curvature over-reads, usually the over-registration will be small unless waves with high energy content are encountered.

7 FUNCTIONAL REQUIREMENTS

7.1 The meter shall respond rapidly and consistently to changes in velocity: the manufacturer shall state the expected response rates.

7.2 Spare parts shall be fully interchangeable, so as to have uniform functional characteristics to cause less than 2% divergence from the normal rating curve and to facilitate easy replacement of worn of damaged elements.

7.3 The current meter shall offer minimum resistance to flow.

7.4 The construction shall be simple to admit all parts being taken but easily cleaned and refitted and also sufficiently rugged to maintain calibration under conditions normally encountered in the final.

7.5 The current meter shall be provided with facilities for dynamic balancing (*see* **6.1.1** and **6.1.2**) in the form of a counterweight adjustment.

7.6 It shall be provided with facilities for mounting on a cable suspension as well as on a hanger bar or a wading rod.

7.7 It shall be provided with facilities for attaching to it sounding (fish) weight.

8 CONSTRUCTION FEATURES OF CURRENT METERS

8.1 General

8.1.1 *Cup Type*

A cup type current meter shall generally consist of:

a) a rotor revolving about a vertical shaft;
b) a hub assembly;
c) bearings;
d) a main frame or yoke;
e) a chamber containing the signal generation mechanism;
f) tail fin; and
g) a means of attaching the instrument to the suspension equipment.

8.1.2 *Propeller Type (Including Savonius Type Rotors)*

a) a rotor that is either a propeller revolving about a fixed axis or a revolving set composed of the propeller and axis;
b) two bearings;
c) a device giving a signal indicating movement of the rotor;
d) a means of attaching the instrument to the suspension equipment;
e) a streamlined body (not applicable to savonius type);
f) tail fin; and
g) a means of attaching the instrument to the suspension equipment.

NOTE — A means of providing directional control to the meter in the current meter in the current will generally be provided. This may be either a part of the suspension equipment or an integral part of the meter.

8.2 Rotor

8.2.1 *Cup Type*

The rotor will generally be constructed of six hollow conical cups, fixed in the same horizontal plane at equally spaced intervals (equal angles) to a frame mounted on a vertical shaft. The assembly shall be retained in the yoke by means of the upper shaft bearing and a lower pointed bearing consisting of a central pivot and a bearing cup.

8.2.2 *Propeller Type*

The current meter may be provided with a single propeller type rotor or with several interchangeable ones each having a different pitch and/or diameter. Each propeller shall consist of multiple vanes or helical screw blades that generally rotate about a horizontal axis. The propellers should be made from material which will not allow them to be easily distorted.

8.2.3 *Savonius Type*

The rotor consists of an assembly of about six to eight turbine type curved vanes (or straight blades) built around a vertical axis. The rotors shall be made from a material which will not allow it to be easily distorted or corroded even in saline waters.

8.3 Bearings

The resisting torque of the bearings shall be as small as possible and shall be constant during use. Bearings shall be lubricated as stated by the manufacturer. Provision shall be made to ensure that silt and water do not enter the bearings except as required for water-lubricated bearings.

8.4 Means of Registering Rotor Revolutions

8.4.1 *Signals*

The revolutions of the rotor shall, by means of mechanical contacts or by means of optical or other devices, generate a clear and positive signals at all velocities within the effective range of the meter. It is permissible to provide a means of multiplying or dividing the signal pulse rate to suit counting equipment with a limited range of operation. If electrical connections are used in the equipment, they should be appropriately protected against short-circuiting and appropriately waterproofed.

8.4.2 *Registration Device*

Arrangements shall be provided to indicate by audible note or visual display or registration on a suitable media (printer/magnetic tape) number of revolutions or revolution rate or velocity of flow.

8.5 Directional Control

Directional control shall be provided by means of tail fins or other devices to enable the meter to align itself with the stream flow and to remain stable in that position throughout the full range of calibrated velocities. The directional control may be either provided by the suspension system or provided by tail fins or other devices that are attached to or are an integral part of the meter.

8.6 Response Behaviour

The manufacturer shall specify the minimum speed of response which is defined as the lowest speed at which the current meter will initiate and maintain steady motion. The manufacturer shall also state the consistency of response together with tolerances to changes in velocity.

8.7 Hydrostatic Pressure

The manufacturer shall state the maximum hydrostatic pressure to which the instrument may be subjected.

8.8 Conductivity of Water

The manufacturer shall stipulate the maximum conductivity of water in which the meter can be used.

9 CONSTRUCTIONAL MATERIALS

9.1 The meter shall be constructed of corrosion-resistant materials throughout or of materials that are effectively protected against conditions encountered in natural medium where measurement are proposed to be taken. The use of the meter in silty or saline waters may reduce the life of the meter.

9.2 The rotors preferably be constructed of such material whose specific gravity should be as close to that of the fluid whose flow velocity is intended to be measured (to enable the energy transference from the fluid to the rotor with least delay).

10 CALIBRATION (OR RATING)

10.1 General

10.1.1 The calibration of current meters involves experimental determination of the relationship between velocity of flow and rate of revolution of rotor (usually expressed as revolutions per second) and provided as a calibration curve or calibration (rating) relationship.

10.1.2 The calibration (rating) of a current meter will normally be valid only for that range of velocities for which it has been manufactured and calibrated and for use with a similar liquid to that which was used in its calibration. Extrapolation is permissible to higher velocities provided that sufficient calibration data exist for meters of a similar type at these higher velocities and that a greater uncertainty is accepted. Any current meter new or old requires periodical calibration.

10.2 Conformity

10.2.1 All calibration shall be carried out in accordance with relevant Indian Standard on calibration.

10.3 Type of Calibration (Rating)

A current meter shall have individual calibration (rating) where the relation of velocity to response is based on a rating of that particular meter. Each meter shall be calibrated to produce individual ratings.

10.4 Equation

10.4.1 From the calibration data, manufacturer or rating laboratories shall supply a rating table for convenience for use in the field and shall also specify the equation of the rating curve derived from the data and the minimum speed necessary to produce a representative sensing of the fluid motion. This speed is the lowest speed at which the current meter will initiate and maintain steady motion. The actual limits of the rating shall be stated.

10.5 Recalibration

Each meters shall be recalibrated (re-rated) whenever its performance is doubtful. Recalibration on routine basis shall be carried out at yearly intervals or after 300 h of use, whichever is the shorter.

10.6 Type of Suspension

The performance of a meter may be affected by its mode of suspension and the sounding weight used.

For individual ratings, it is advisable that the calibration be carried out using the means of suspension and the sounding weight intended to be used during a measurement. The distance from the bottom of the sounding weight to the meter, for the calibration configuration, shall be specified by the rating laboratory or manufacturer.

It is possible to derive by experimental coefficients which can be applied to gauging data to correct for the effects (if any) of different sounding weight and different means, size and shape of suspension.

Such coefficients are applicable only to the specific combination for which data have been experimentally obtained.

10.7 Uncertainty

As a check for goodness of fit of the rating curve, the manufacturer or rating laboratories shall state the standard error of the data for the lower and upper limits of calibration, and for at least two intermediate points. The standard error shall be stated as a percentage of the velocity class and shall be related to the 95% confidence limits.

The scatter of the points about the rating curve for each velocity class shall be approximately normal so that the errors will be compensating.

10.8 Operating Conditions

Attention should be paid to possible variations in the rating due to changes in liquid density or viscosity.

11 TOLERANCE

Maximum permissible tolerances in the velocity measurement with new current meters shall be as follows:

Velocity around 0·3 m/s	± 1 percent
Velocity greater than 0·3 m/s	± 0·5 percent

12 MAINTENANCE

12.1 General

Under conditions of normal operation, the user should follow recommended check procedures before and after each discharge measurement, as laid down in the manufacturer's operation and servicing manual. In the event of more comprehensive instructions not being provided the procedures specified in 12.1.1 to 12.1.3 should be followed.

12.1.1 *Examination*

The meter shall be examined before and after each discharge measurement for worn or damaged bearings, proper shaft alignment, correct operation of contact points and deformation of the yoke or cup-wheel in the case of cup type meters or as rotor assembly in case of savonius type meters. All moving parts should be carefully inspected and checks performed to ensure operation in accordance with specifications. Particular attention should be paid to equipment which has been in storage for a long period of time.

12.1.2 *Inspection*

For inspection, it shall be possible to dismantle and reassemble the current meter assembly in the field, without specialized workshop facilities and by personnel without specialist training. Such tools as are required to carry out this operation shall be supplied as standard accessories.

On-site removal and replacement of the rotor on its shaft shall be possible with minimum disturbance to the bearing assembly, and preferably without removing the bearing assembly from the instrument.

12.1.3 *Signal Test*

Before use, the meter shall be tested for correct operation. By turning the rotor slowly, the number of rotations shall be compared with the number of pulses received. For current meters with a generator it shall be checked that output varies with rotor speed.

12.2 Spin Test

12.2.1 *Current Meters with Ball Bearings or with a Pivot Bearing*

If no, special instruments are provided by the manufacturer, the test described below may be carried out after the meter has been lubricated and assembled ready for use. For a new cup type current meter the spin time shall be a minimum of 75 seconds.

Place the meter in the normal operating attitudes, with the rotor protected from air currents. Spin the rotor by hand. As it nears its stopping point, observe its motion carefully to see whether the stop is abrupt or gradual. If the stop is abrupt, the cause shall be found and corrected before the meter is used. A pre-specified minimum spin time should be observed for a meter in good condition.

12.2.2 *Current Meters Without Ball Bearings*

The design of meters without ball bearings prevents the meter from working properly in air. The manufacturer shall recommend a simple check procedure to ensure proper operation.

12.3 Cleaning and Lubrication

After each discharge measurement, or more frequently for extended measurements, all bearing surfaces (including any pivot) shall be thoroughly cleaned and, where appropriate, lubricated. If bearings require lubrication to be applied for use of the current meter in the field, the lubricant used shall have the same viscosity characteristics as the lubricant used at the time of calibration; this lubricant shall have the same or equivalent specifications as that recommended by the manufacturer.

12.4 The history sheet of the current meter shall be maintained in the proforma given below :

HISTORY SHEET AND CALIBRATION DATA

Name of manufacturer ....

Date of manufacture ....

Serial number ....

Source of manufacture ....

Sl No.	Date of Start and Stoppage of Use and Re-use	Date of Calibration	Place of Calibration	Result of Test	Equations	Remarks Giving Condition of Meter, Repair If Any, Reason for Stoppage, Use and Re-use, etc
(1)	(2)	(3)	(4)	(5)	(6)	(7)

12.5 Transport and Storage

A suitable protective instrument case shall be provided by the manufacturer in which the current meter may be stored when not in use. Suitable storage shall also be provided in the case for the tools required for instrument maintenance.

Provision shall be made for the storage and transportation of the current meter and its components in such a manner that the bearings and other parts of the meter can be protected from wear and from damage resulting from vibration or shock.

13 OPERATIONAL AND SERVICING MANUAL

A comprehensive operational and servicing manual should be supplied with each instrument. It should present full instructions, illustrated where necessary and include appropriate circuit diagrams with component values. The manual should contain sections on the following:

a) normal maintenance, servicing on site, checking procedure including recommended screw torques;

b) spares list, including a list of contributing manufacturers;

c) lubricant and sealant details, including lubricant and compound specifications;

d) preparations necessary for transport and storage;

e) details of power source, if any and appropriate rates and duration of recharge;

f) details of electrical and (or) electronic circuitry (including component values) with circuit diagrams and test procedures.

14 ACCESSORIES AND SPARES

14.1 Essential site spares and maintenance spares for at least two years, as well as accessories are to be provided as per recommendation of the manufacturer.

14.2 Appropriate fish weights shall be provided to cover the velocity ranges for which it is expected to be used.

15 MARKING

Current meter shall be engraved with source of manufacture, trade mark, year of manufacture and the serial number for each delivery.

ANNEX A

(*Clause* 5.2)

TYPICAL DETAILS OF A STANDARD SIZE CUP TYPE CURRENT METER WITH FRONT HOOP

A-0 GENERAL

A-0.1 Details of various parts and their arrangement of the such type of current meter are shown in Fig. 1, 2, 3, 4. The counter is of electronic type. The signal generating system has magnet and read switch assembly.

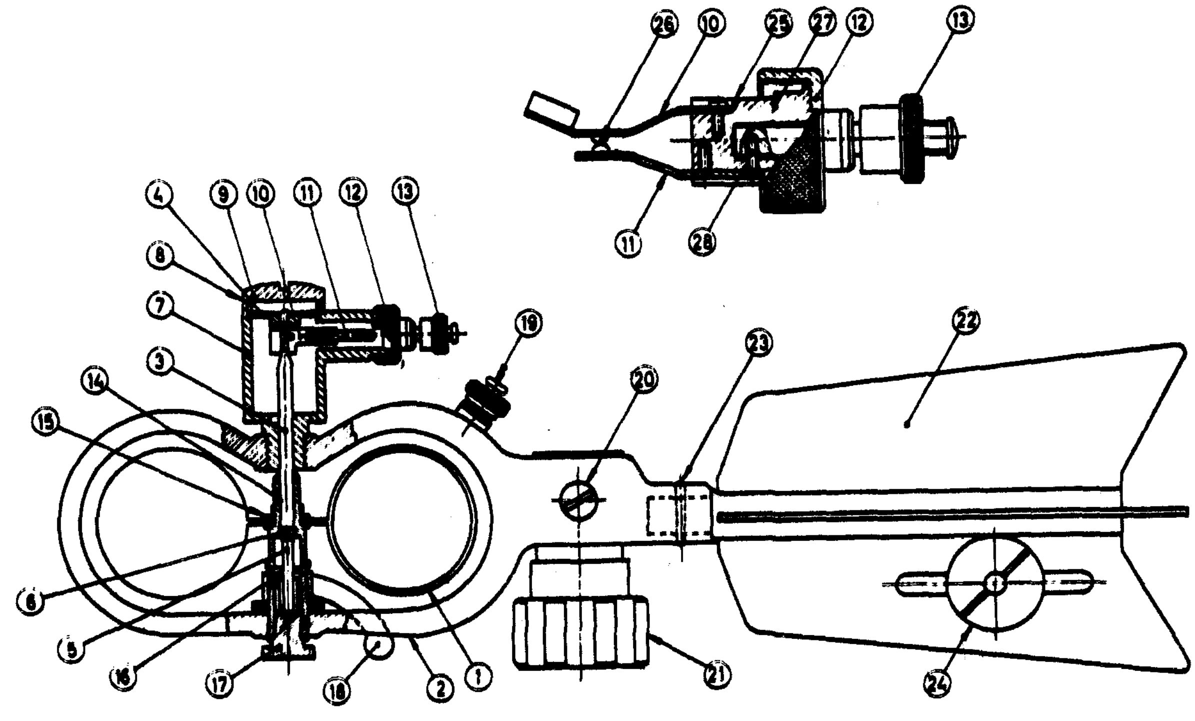
A-0.2 Material to be Used

A-0.2.1 The meter shall be constructed of non-corrosive materials and for:

a) *Yoke (Main Frame)* — Manganese bronze casting.
b) *Bucket Wheel Cups* — Brass sheet.
c) *Pivot* — Rust proof, hardened, and tempered close grained tool steel with minimum Vicats diamond pyramid hardness No. 640 (Rockwell C-57).
d) *Pivot Bearing* — Rust proof, hardened and tempered steel with minimum Vicats diamond pyramid hardness No. 720 (Rockwell C-61).
e) *Contact Chamber* — Brass sheet.
f) *Contact Point* — Platinum.
g) *Contact Spring*

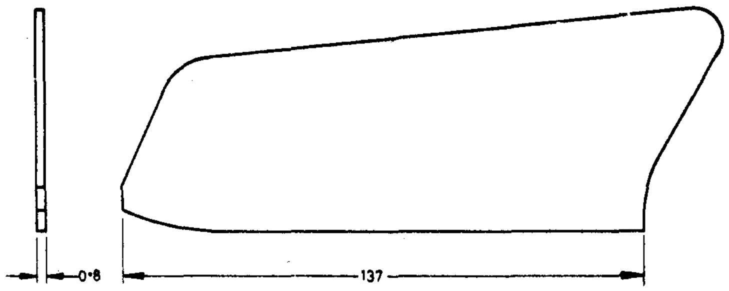
NOTE — The construction of miniature (Pigmy), which is without front hoop is similar except for:

a) The size of the bucket wheel is 5 cm instead of 12·7 cm and all other parts are suitably diminished.
b) Contact chamber being an integral part of the yoke.
c) There being no provision for mounting on a cable suspension as it is always mounted on a wading rod or hanger bar.
d) There are no tail fins.
e) Sometimes it may not have bucket wheel raising nut and under those conditions a soft metallic plug should be provided to replace the pivot while the meter is being transported or stored.

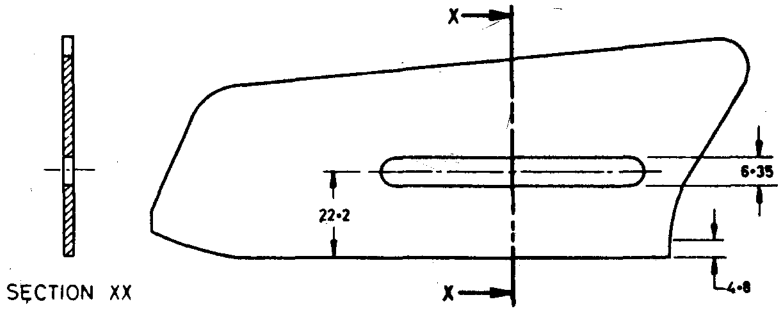


1. Bucket-wheel cup
2. Yoke
3. Spindle
4. Upper spindle bearing
5. Pivot
6. Bearing cup
7. Contact chamber
8. Sealing washer
9. Cap for contact chamber
10. Contact spring
11. Insulated contact bar
12. Contact breaker clamping ring
13. Terlminal knob
14. Spindle collar
15. Bucket Hexagonal lock nut
16. Pivot lock nut
17. Pivot holder
18. Bucket-raising level
19. Earth terminal
20. Central adaptor pivot
21. Adaptor clamp
22. Tail fin
23. Tail fin securing pin
24. Tail fin counter-weight
25. Contact to earth
26. Platinum contacts
27. Vulcanite mount
28. Insulated contact-bar securing screw

FIG. 1 CURRENT METER (CUP TYPE)



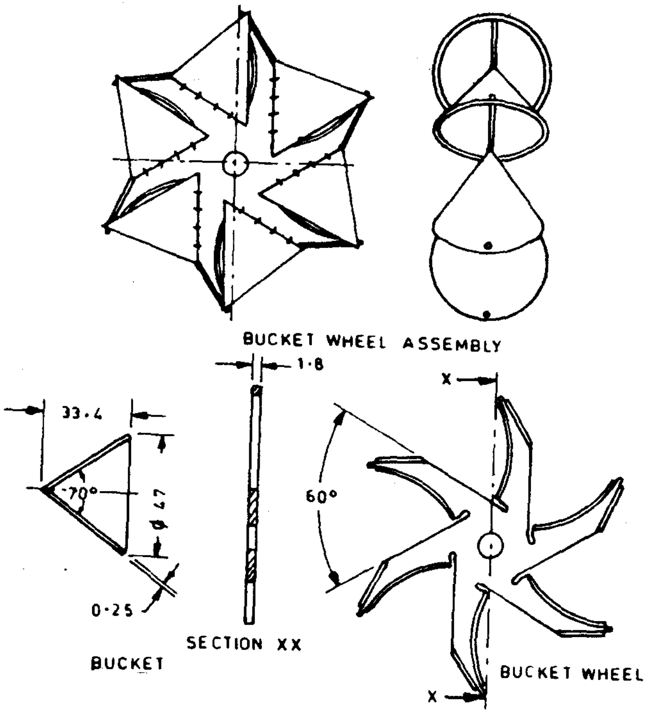
FINS (3-OFF)



FIN WITH SLOT (1-OFF)

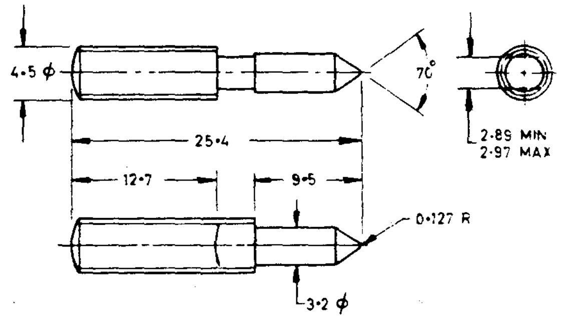
All dimensions in millimetres.

FIG. 2 DETAILS OF FIN

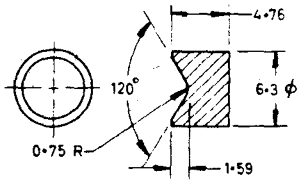


All dimensions in millimetres.

FIG. 3 BUCKET WHEEL FOR CURRENT METER



4 A PIVOT



4 B PIVOT CUP

All dimensions in millimetres.

FIG. 4 PIVOT AND PIVOT CUP

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